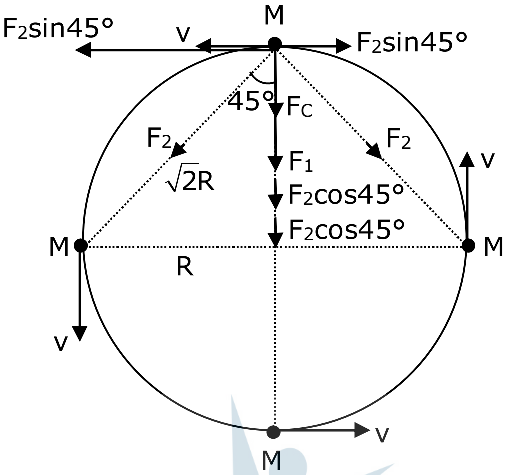
PHYSICS
JEE-MAIN (February-Attempt) 24 February (Shift-1) Paper

Section - A

1. Four identical particles of equal masses 1 kg made to move along the circumference of a circle of radius 1 m under the action of their own mutual gravitational attraction. The speed of each particle will be -

(1) $\frac{\sqrt{(1+2\sqrt{2})G}}{2}$ (2) $\sqrt{G(1+2\sqrt{2})}$ (3) $\sqrt{\frac{G}{2}\left(2\sqrt{2}-1\right)}$ (4) $\sqrt{\frac{G}{2}\left(1+2\sqrt{2}\right)}$

Sol. (1)



$\Rightarrow$ By resolving force F_2, we get

$\Rightarrow F_1 + F_2 \cos 45° + F_2 \cos 45°$

$\Rightarrow F_1 + 2F_2 \cos 45° = F_c$

F_c = centripital force = $\frac{MV^2}{R}$

$$\Rightarrow \frac{GM^2}{(2R)^2} + \left[\frac{2GM^2}{\left(\sqrt{2}R\right)^2}\cos 45^\circ\right] = \frac{MV^2}{R}$$

$$\Rightarrow \frac{GM^2}{4R^2} + \frac{2GM^2}{2\sqrt{2}R^2} = \frac{MV^2}{R}$$

$$\Rightarrow \frac{GM}{4R} + \frac{GM}{\sqrt{2}.R} = V^2$$

$$\Rightarrow V = \sqrt{\frac{GM}{4R} + \frac{GM}{\sqrt{2}.R}}$$

$$\Rightarrow V = \sqrt{\frac{GM}{R}\left[\frac{1+2\sqrt{2}}{4}\right]}$$

$$\Rightarrow V = \frac{1}{2}\sqrt{\frac{GM}{R}\left(1+2\sqrt{2}\right)}$$

(given : mass = 1 kg, radius = 1 m)

$$\Rightarrow v = \frac{1}{2}\sqrt{G(1+2\sqrt{2})}$$

2. Consider two satellites S_1 and S_2 with periods of revolution 1 hr. and 8 hr. respectively revolving around a planet in circular orbits.The ratio of angular velocity of satellite S_1 to the angular velocity of satellite S_2 is -

(1)8 : 1 (2)1 : 8 (3)2 : 1 (4) 1 : 4

Sol. **(1)**

We know that $\omega = \frac{2\pi}{T}$

given : Ratio of time period

$\frac{T_1}{T_2} = \frac{1}{8}$

$\Rightarrow \omega \propto \frac{1}{T}$

$\Rightarrow \frac{\omega_1}{\omega_2} = \frac{T_2}{T_1}$

$\Rightarrow \frac{\omega_1}{\omega_2} = \frac{8}{1}$

$\Rightarrow \omega_1 : \omega_2 = 8 : 1$

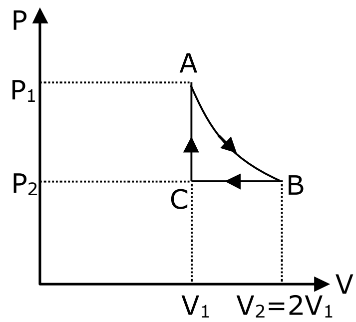
3. n mole of a perfect gas undergoes a cyclic process ABCA (see figure) consisting of the following processes –

A→B : Isothermal expansion at temperature T so that the volume is doubled from V_1 to $V_2 = 2V_1$ and pressure changes from P_1 to P_2.

B → C : Isobaric compression at pressure P_2 to initial volume V_1.

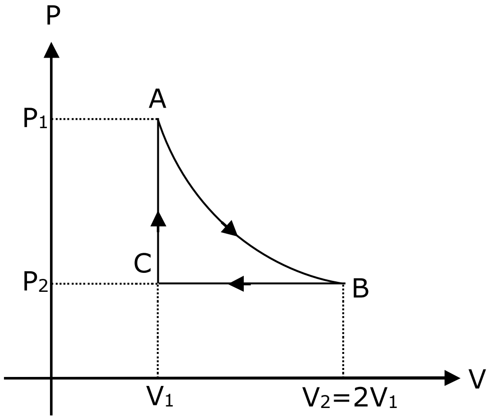
C → A : Isochoric change leading to change of pressure from P_2 to P_1.

Total workdone in the complete cycle ABCA is –



(1)0 (2)$nRT\left(\ln 2 + \frac{1}{2}\right)$ (3)$nRT\ln 2$ (4) $nRT\left(\ln 2 - \frac{1}{2}\right)$

Sol. **(4)**



$A \rightarrow B$ = isotheraml process

$B \rightarrow C$ = isobaric process

$C \rightarrow A$ = isochoric process

also, $V_2 = 2V_1$

work done by gas in the complete cycle ABCA is –

$\Rightarrow w = w_{AB} + w_{BC} + w_{CA}$ ....(1)

$\Rightarrow w_{CA} = 0$, as isochoric process

$\Rightarrow w_{AB} = 2P_1V_1 \ln\left(\frac{V_2}{V_1}\right) = 2\ nRT \ln(2)$

$\Rightarrow w_{BC} = P_2(V_1 - V_2) = P_2(V_1 - 2V_1) = -P_2V_1 = -nRT$

$\Rightarrow$Now put the value of w_{AB}, w_{BC} and w_{CA} in equation, we get

$\Rightarrow w = 2nRT \ln(2) - nRT + 0$

$\Rightarrow w = nRT[2\ln(2) - 1]$

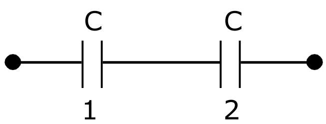
$\Rightarrow w = nRT[\ln(2) - \frac{1}{2}]$

4. Two equal capacitors are first connected in series and then in parallel. The ratio of the equivalent capacities capacities in the two cases will be -

(1)2 : 1 (2)1 : 4 (3)4 : 1 (4) 1 : 2

Sol. **(2)**

Given that first connection



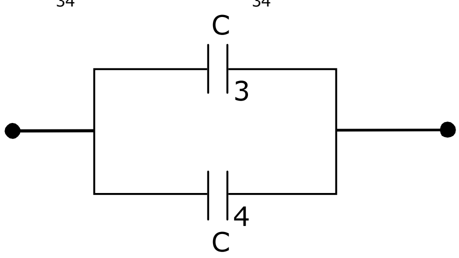
$\Rightarrow \frac{1}{C_{12}} = \frac{1}{C} + \frac{1}{C} \Rightarrow C_{12} = \frac{C}{2}$

Second connection

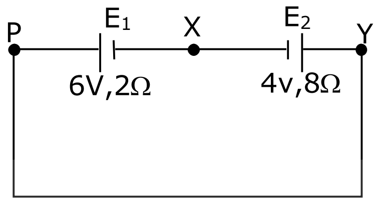
$C_{34} = C + C = 2\ C$

Now, the ratio of equivalent capacities in the two cases will be –

$$\Rightarrow \frac{C_{12}}{C_{34}} = \frac{C/2}{2C} \Rightarrow \frac{C_{12}}{C_{34}} = \frac{1}{4}$$

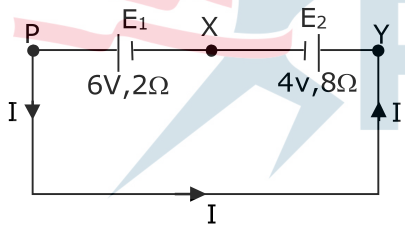


5. A cell E_1 of emf 6V and internal resistance 2Ω is connected with another cell E_2 of emf 4V and internal resistance 8Ω (as shown in the figure). The potential difference across points X and Y is –



(1)3.6V (2)10.0V (3)5.6V (4) 2.0V

Sol. **(3)**



emf of E_1 = 6v

r_1 = 2 Ω

emf of E_2= 4 Ω

r_2 = 8Ω

$|v_x - v_y|$ = potential difference across points x and y

E_{eff} = 6 – 4 = 2 V

R_{eq} = 2 + 8 = 10 Ω

So, current in the circuit will be

$$\Rightarrow I = \frac{E_{eff}}{R_{eq}} \Rightarrow I = \frac{2}{10} = 0.2 \text{ A}$$

Now, potential difference across points X and Y is

$|v_x - v_y| = E + iR$

$\Rightarrow |v_x - v_y| = 4 + 0.2 \times 8 = 5.6$ V

$\Rightarrow |v_x - v_y| = 5.6$ v

6. If Y,K and η are the values of Young's modulus, bulk modulus and modulus of rigidity of any material respectively. Choose the correct relation for these parameters.

(1) $K = \frac{Y\eta}{9\eta - 3Y}$ N/m^2 (2) $\eta = \frac{3YK}{9K + Y}$ N/m^2

(3) $Y = \frac{9K\eta}{3K - \eta}$ N/m^2 (4) $Y = \frac{9K\eta}{2\eta + 3K}$ N/m^2

Sol. **(1)**

$\Rightarrow y = 3k(1 - 2\sigma)$

$\Rightarrow \sigma = \frac{1}{2}\left(1 - \frac{y}{3k}\right)$ ....(1)

$\Rightarrow y = 2\eta(1 + \sigma)$

$\Rightarrow \sigma = \frac{y}{2\eta} - 1$ ....(2)

by comparing equation (1) and (2), we get

$\Rightarrow \frac{y}{2\eta} - 1 = \frac{1}{2}\left(1 - \frac{y}{3k}\right)$

$\Rightarrow \frac{y}{\eta} - 2 = 1 - \frac{y}{3k}$

$\Rightarrow \frac{y}{\eta} = 1 + 2 - \frac{y}{3k} \Rightarrow \frac{y}{\eta} = 3 - \frac{y}{3k}$

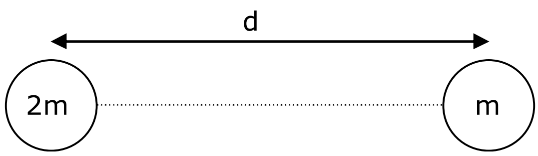
$\Rightarrow \frac{y}{3k} = 3 - \frac{y}{\eta} \Rightarrow \frac{y}{3k} = \frac{3\eta - y}{\eta}$

$\Rightarrow k = \frac{\eta y}{9\eta - 3y}$

7. Two stars of masses m and 2m at a distance d rotate about their common centre of mass in free space. The period of revolution is -

(1) $2\pi\sqrt{\frac{d^3}{3Gm}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{3Gm}{d^3}}$ (3) $\frac{1}{2\pi}\sqrt{\frac{d^3}{3Gm}}$ (4) $2\pi\sqrt{\frac{3Gm}{d^3}}$

Sol. **(1)**



$\Rightarrow \frac{G(m)(2m)}{d^2} = m\omega^2 \times \frac{2d}{3}$

$\Rightarrow \frac{2Gm}{d^2} = \omega^2 \times \frac{2d}{3}$

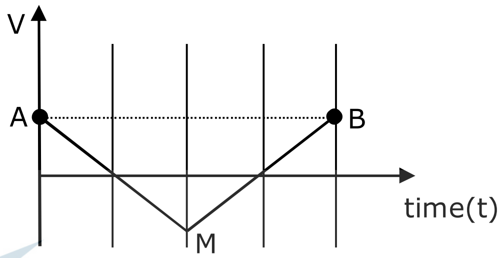
$\Rightarrow \omega^2 = \dfrac{3Gm}{d^3}$

$\Rightarrow \omega = \sqrt{\dfrac{3Gm}{d^3}}$

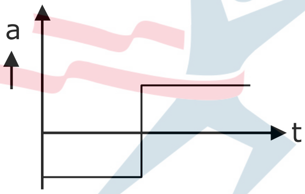
we know that, $\omega = \dfrac{2\pi}{T}$ so $T = \dfrac{2\pi}{\omega}$

$\Rightarrow T = \dfrac{2\pi}{\sqrt{\dfrac{3Gm}{d^3}}} \Rightarrow T = 2\pi\sqrt{\dfrac{d^3}{3Gm}}$

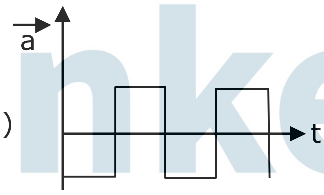
8. If the velocity-time graph has the shape AMB, what would be the shape of the corresponding acceleration-time graph ?



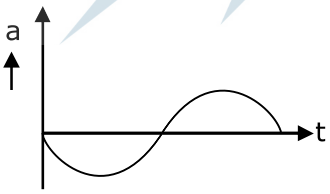
(1)



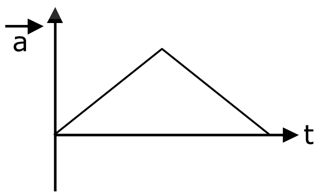
(2)



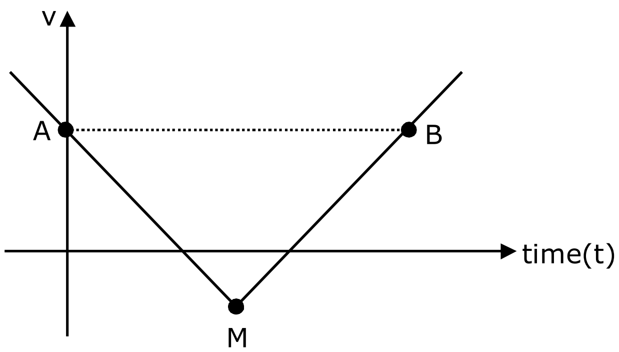
(3)



(4)



Sol. **(1)**



$a = \dfrac{dv}{dt}$ = slope of (v – t) curve

If m = +ve, then equation of straight line is

$y = mx + c \Rightarrow v = mt + c$ (for MB)

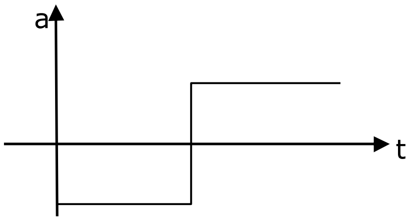
If m =-ve, then equation of straight line is

$y = -mx + c \Rightarrow v = -mt + c$ (for AM)

If we differentiate equation (1) and (2), we get

$a_{MB} = +ve = m$

$a_{AM} = -ve = -m$, so graph of (a-t) will be



9. Given below are two statements :

Statement – I: Two photons having equal linear momenta have equal wavelengths.

Statement-II: If the wavelength of photon is decreased, then the momentum and energy of a photon will also decrease.

In the light of the above statements, choose the correct answer from the options given below.

(1)Statemnet-I is false but Statement-II is true

(2)Both Statement-I and Statement-II are true

(3)Both Statement-I and Statement-II are false

(4) Statement-I is true but Statement-II is false

Sol. **(4)**

By theory

10. A current through a wire depends on time as $i = \alpha_0 t + \beta t^2$

where $\alpha_0 = 20$ A/s and $\beta = 8$ As^{-2}. Find the charge crossed through a section of the wire in 15 s.

(1)2100 C (2)260 C (3)2250 C (4) 11250 C

Sol. **(4)**

given :$i = \alpha_0 t + \beta t^2$

$\alpha = 20$ A/s and $\beta = 8As^{-2}$

t = 15 sec

we know that, $i = \frac{dq}{dt} \Rightarrow \int_0^t idt = \int_0^Q dq$

$\Rightarrow \int_0^{15} (\alpha_0 t + \beta t^2)dt = \int_0^Q dq$

$\Rightarrow Q = \left[\frac{\alpha_0 t^2}{2} + \frac{\beta t^3}{3}\right]_0^{15}$

$$\Rightarrow Q = \frac{20 \times 15 \times 15}{2} + \frac{8 \times 15 \times 15 \times 15}{3} - 0$$

$\Rightarrow Q = 11250$ C

11. match List I with List II

List-I	List-II
(a) Isothermal	(i) Pressure constant
(b) Isochoric	(ii) Temperature constant
(c) Adiabatic	(iii) Volume constant
(d) Isobaric	(iv) Heat content is constant

Choose the correct answer from the options given below –

(1)(a) – (ii), (b) – (iv), (c) – (iii), (d) – (i)

(2)(a) – (ii), (b) – (iii), (c) – (iv), (d) – (i)

(3)(a) – (i), (b) – (iii), (c) – (ii), (d) – (iv)

(4) (a) – (iii), (b) – (ii), (c) – (i), (d) – (iv)

Sol. **(2)**

(a)→(ii), (b)→(iii), (c)→(iv), (d)→(i),

By theory

In isothermal process, temperature is constant.

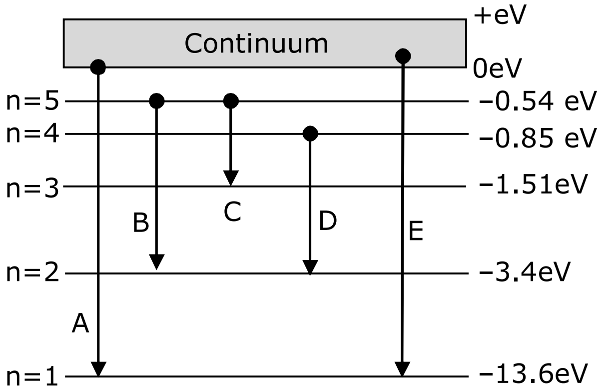
In isochoric process, volume is constant.

In adiabatic process, heat content is constant.

In isobaric process, pressure is constant.

12. In the given figure, the energy levels of hydrogen atom have been shown along with some transitions marked A,B,C,D and E.

The transitions A,B and C respectively represents –



(1)The series limit of Lyman series, third member of balmer series and second member of paschen series

(2)The first member of the Lyman series, third member of Balmer series and second member of paschen series

(3)The ionization potential of hydrogen, second member of Balmer series and third member of Paschen series

(4) The series limit of Lyman series, second memebr of Balmer series and second member of Paschen series.

Sol. **(1)**

A $\rightarrow$ series limit of lyman.

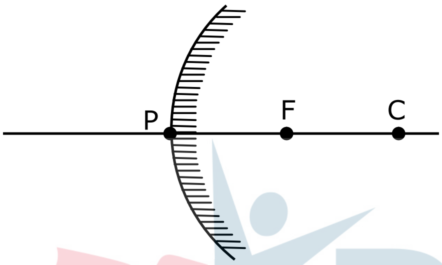
B $\rightarrow$ 3^{rd} member of Balmer series.

C $\rightarrow$ 2^{nd} member of Paschen series.

13. The focal length f is related to the radius of curvature r of the spherical convex mirror by -

(1) $f = r$ (2) $f = -\frac{1}{2}r$ (3) $f = +\frac{1}{2}r$ (4) $f = -r$

Sol. **(3)**



So, $\frac{R}{2} = f$

$F = +\frac{1}{2} R$

14. Moment of inertia (M.I.) of four bodies, having same mass and radius, are reported as –

I_1 = M.I. of thin circular ring about its diameter,

I_2 = M.I. of circular disc about an axis perpendicular to disc and going through the centre,

I_3 = M.I. of solid cylinder about its axis and

I_4 = M.I. of solid sphere about its diameter.

Then :-

(1)$I_1 = I_2 = I_3 < I_4$ (2)$I_1 + I_2 = I_3 + \frac{5}{2} I_4$

(3)$I_1 + I_3 < I_2 + I_4$ (4) $I_1 = I_2 = I_3 > I_4$

Sol. **(4)**

Given$\Rightarrow$ I_1 = M.I. of thin circular ring about its diameter

I_2 = M.I. circular disc about an axis perpendicular to disc and going through the centre.

I_3 = M.I. of solid cylinder about its axis

I_4 = M.I. of solid sphere about its diameter

we know that,

$I_1 = \frac{MR^2}{2}$, $I_2 = \frac{MR^2}{2}$, $I_3 = \frac{MR^2}{2}$

$I_4 = \frac{2}{5} MR^2$

So, $I_1 = I_2 = I_3 > I_4$

15. The workdone by a gas molecule in an isolated system is given by, $W = \alpha\beta^2 e^{-\frac{x^2}{\alpha kT}}$, where x is the displacement, k is the Boltzmann constant and T is the temperature. α and β are constants. Then the dimensions of β will be -

(1) $[M^0LT^0]$ (2) $[M^2LT^2]$ (3) $[MLT^{-2}]$ (4) $[ML^2T^{-2}]$

Sol. **(3)**

given : work $= \alpha.\beta^2.e^{-\frac{x^2}{\alpha.k.T}}$

k = boltzmann constant

T = temperature

x = displacement

we know that, $\frac{x^2}{\alpha.k.T}$ = dimensionless

$\left[\frac{x^2}{\alpha.k.T}\right] = [M^0L^0T^0]$

$[\alpha] = \left[\frac{L^2}{K.T}\right]$

$\Rightarrow [K] = [M^1L^2T^{-2}K^{-1}]$

$[T] = [K]$

$\Rightarrow [\alpha] = \left[\frac{L^2}{M^1L^2T^{-2}K^{-1} \times K}\right] \Rightarrow [\alpha] = [M^{-1}T^2]$

$\Rightarrow \omega = \alpha.\beta^2$

$\Rightarrow \frac{[M^1L^1T^{-2}][L^{-1}]}{[M^{-1}T^2]} = [\beta^2] = [M^2L^2T^{-4}]$

$[\beta] = [MLT^{-2}]$

16. If an emitter current is changed by 4mA, the collector current changes by 3.5 mA. The value of β will be -

(1) 7 (2) 0.875 (3) 0.5 (4) 3.5

Sol. **(1)**

Given :

$\Delta I_E = 4$ mA

$\Delta I_C = 3.5$ mA

we know that, $\alpha = \frac{\Delta I_C}{\Delta I_E}$

$\Rightarrow \alpha = \frac{3.5}{4} = \frac{7}{8}$

Also, $\beta = \frac{\alpha}{1-\alpha}$, so

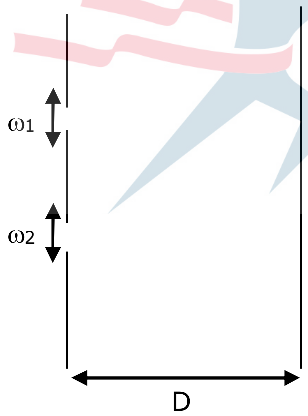
$\beta = \frac{\frac{7}{8}}{1-\frac{7}{8}} = \frac{7}{1}$

$\beta = 7$

17. In a Young's double slit experiment, the width ofthe one of the slit is three times the other slit. The amplitude of the light coming from a slit is proportional to the slit-width. Find the ratio of the maximum to the minimum intensity in the interference pattern.

(1)4 : 1 (2)2 : 1 (3)3 : 1 (4) 1 : 4

Sol. **(1)**



given : $\omega_2 = 3\omega_1$

also, $A \propto \omega$

$\frac{\omega_1}{\omega_2} = \frac{1}{3}$ ...(1)

Assume $\omega_1 = x$, $\omega_2 = 3x$

we know that

$I_{max} = (A_1 + A_2)^2$, and

$I_{min} = (A_1 - A_2)^2$

$$\frac{A_1}{A_2} = \frac{\omega_1}{\omega_2} \qquad ....(2)$$

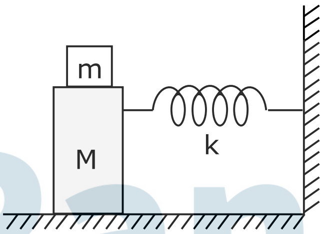
from equation (2) we can say that

A_1 = A and A_2 = 3A

Now, $\frac{I_{max}}{I_{min}} = \frac{(A+3A)^2}{(A-3A)^2} = \frac{16A^2}{4A^2} = \frac{4}{1}$

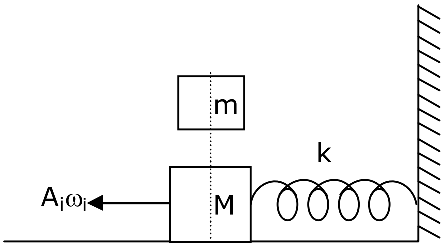
$\Rightarrow \frac{I_{max}}{I_{min}} = \frac{4}{1}$

18. In the given figure, a mass M is attached to a horizontal spring which is fixed on one side to a rigid support. The spring constant of the spring is k. The mass oscillates on a frictionless surface with time period T and amplitude A. When the mass is in equilibrium position, as shown in the figure, another mass m is gently fixed upon it. The new amplitude of oscillation will be -

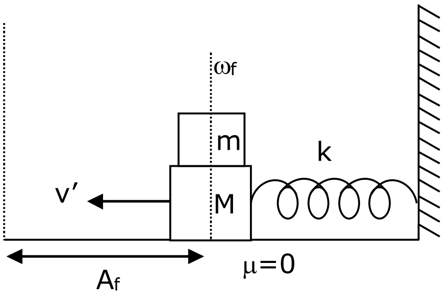


(1) $A\sqrt{\frac{M}{M+m}}$ (2) $A\sqrt{\frac{M}{M-m}}$ (3) $A\sqrt{\frac{M-m}{M}}$ (4) $A\sqrt{\frac{M+m}{M}}$

Sol. **(1)**



Before placing



After placing

We know that $\omega = \sqrt{\frac{k}{m}}$ and $\omega_i = \sqrt{\frac{k}{M}}$ $A_i = A$

Also, momentum is conserved just before and just after the block of mass (m) is placed because there is no implusive force. So -

$MA_i\omega_i = (M + m)\, v'$

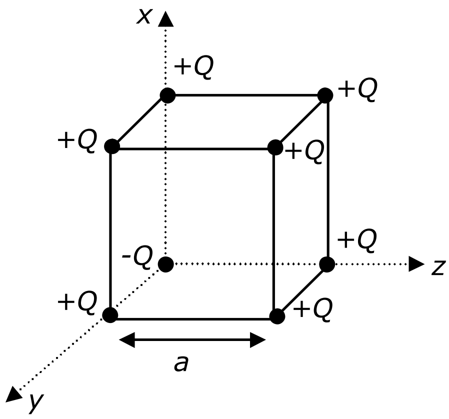
$v' = \frac{MA_i\omega_i}{(M+m)} \Rightarrow v' = A_f\omega_f$

$\frac{MA\omega_i}{(M+m)} = A_f\sqrt{\frac{K}{(M+m)}}$

$\Rightarrow \frac{MA\sqrt{\frac{K}{M}}}{M+m} \times \sqrt{\frac{M+m}{K}} = A_f$

$\Rightarrow A_f = A\sqrt{\frac{M}{(M+m)}}$

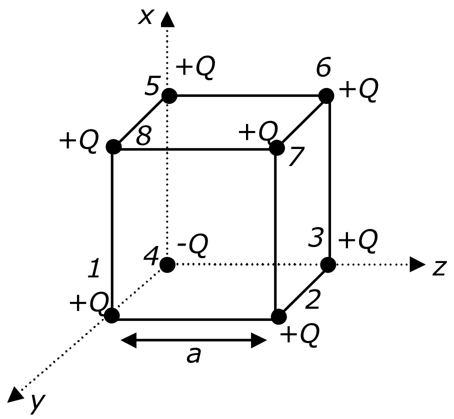
19. A cube of side 'a' has point charges +Q located at each of its vertices except at the origin where the charge is –Q. The electric field at the centre of cube is :



(1) $\frac{2Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$ (2) $\frac{Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

(3) $\frac{-2Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$ (4) $\frac{-Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

Sol. **(3)**



If only +Q charges are placedat the corners of cube of side a then electric field at the centre of the cube will be zero.

But in the given condition one (-Q) is placed at one corner of cube so here

$E_1 = E_6$, $E_2 = E_5$ and $E_3 = E_8$ (So it will cancel out each other so electric field at centre is due to Q_4 and Q_7.

Here electric field at centre = 2 $(E.f.)_4$

As, $|E_4| = |E_7|$

$$(E.F)_C = \frac{2kQ}{\left(\frac{\sqrt{3}a}{2}\right)^2} = \frac{8KQ}{3a^2} \qquad \left\{\because K = \frac{1}{4\pi\varepsilon_0}\right\}$$

$$(E.F)_C = \frac{2Q}{3a^2\pi\varepsilon_0}$$

In vector form $\Rightarrow \vec{E} = \frac{-2Q}{3a^2\pi\varepsilon_0} \times \left(\frac{\hat{x}+\hat{y}+\hat{z}}{\sqrt{3}}\right)$

20. Each side of a box made of metal sheet in cubic shape is 'a' at room temperature 'T', the coefficient of linear expansion of the metal sheet is 'α'. The metal sheet is heated uniformly, by a small temperature ΔT, so that its new temeprature is $T+\Delta T$. Calculate theincrease in the volume of the metal box-

(1) $\frac{4}{3}\pi a^3\alpha\Delta T$ (2) $4\pi a^3\alpha\Delta T$ (3) $3a^3\alpha\Delta T$ (4) $4a^3\alpha\Delta T$

Sol. **(3)**

volume expansion $\gamma = 3\alpha$

$$\frac{\Delta V}{V} = \gamma\Delta T$$

$\Delta V = V.\gamma\Delta T$

$\Delta V = a^3.\ 3\alpha\Delta T$

SECTION-B

1. A resonance circuit having inductance and resistance 2×10^{-4} H and 6.28 Ω respectively oscillates at 10 MHz frequency. The value of quality factor of this resonator is________.
[π = 3.14]

Sol. **2000**

Given : R = 6.28 Ω

f = 10 MHz

L = 2×10^{-4} Henry

we know that quality factor Q is given by

$\Rightarrow Q = \frac{X_L}{R} = \frac{\omega L}{R}$

also, $\omega = 2\pi f$, so

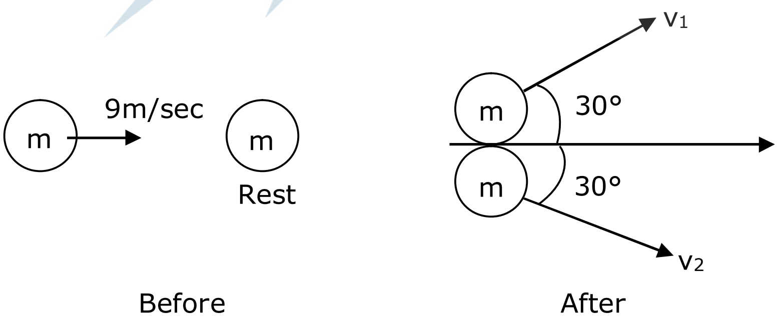
$\Rightarrow Q = \frac{2\pi f L}{R}$

$\Rightarrow Q = \frac{2\pi \times 10 \times 10^6 \times 2 \times 10^{-4}}{6.28} = 2000$

Q = 2000

2. A ball with a speed of 9 m/s collides with another identical ball at rest. After thecollision, the direction of each ball makes an angle of 30° with the original direction. The ratio of velocities of the balls after collision is x : y, where x is __________.

Sol. **1**



Momentum is conserved just before and just after the collision in both x-y direction.

In y-direction

$p_i = 0$

$P_f = m \times \frac{1}{2} v_1 - m \times \frac{1}{2} v_2$

$p_i = p_f$, so

$= \frac{mv_1}{2} - \frac{mv_2}{2} = 0$

$\Rightarrow \frac{mv_1}{2} = \frac{mv_2}{2} \Rightarrow v_1 = v_2$

$\frac{v_1}{v_2} = 1$

3. An audio signal $\upsilon_m = 20\sin 2\pi(1500t)$ amplitude modulates a carrier $\upsilon_c = 80 \sin 2\pi\ (100{,}000t)$. The value of percent modulation is _________.

Sol. 25

Given : $\upsilon_m = 20 \sin \left[100\pi t + \frac{\pi}{4}\right]$

$\upsilon_c = 80 \sin \left[10^4 \pi t + \frac{\pi}{6}\right]$

we know that, modulation index = $\frac{A_m}{A_c}$

from given equations, $A_m = 20$ and $A_c = 80$

percentage modulation index = $\frac{A_m}{A_c} \times 100$

$\Rightarrow \frac{20}{80} \times 100 = 25\%$

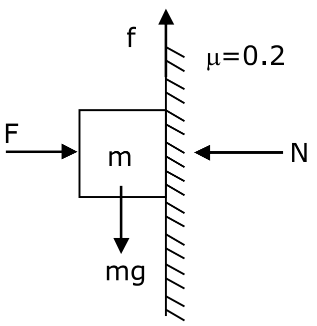
The value of percentage modulation index is

=25

4. The coefficient of static friction between a wooden block of mass 0.5 kg and a vertical rough wall is 0.2. The magnitude of horizontal force that should be applied on the block to keep it adhere to the wall will be _______ N.

$[g = 10\ ms^{-2}]$

Sol. 25



Given : $\mu_s = 0.2$

m = 0.5 kg

g = 10 m/s^2

we know that

$f_s = \mu N$ and ....(1)

To keep the block adhere to the wall

here N = F ...(2)

$f_s = mg$ ....(3)

from equation (1), (2), and (3), we get

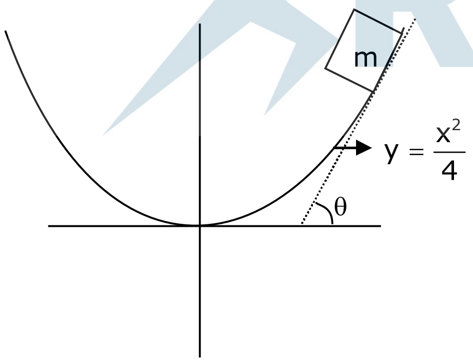
$\Rightarrow mg = \mu F$

$\Rightarrow F = \frac{mg}{\mu} \Rightarrow F = \frac{0.5 \times 10}{0.2}$

F = 25 N

5. An inclined plane is bent in such a way that the vertical cross-section is given by $y = \frac{x^2}{4}$ where y is in vertical and x in horizontal direction. If the upper surface of this curved plane is rough with coefficient of friction $\mu = 0.5$, the maximum height in cm at which a stationary block will not slip downward is ______ cm.

Sol. **25**



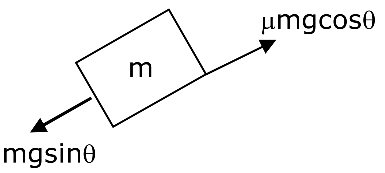
given

$y = \frac{x^2}{4}$

$\mu = 0.5$

condition for block will not slip downward

$mg \sin\theta = \mu mg \cos\theta$



$\Rightarrow \tan\theta = \mu$

and we know that

$\Rightarrow \tan\theta = \frac{dy}{dx}$

$\Rightarrow \frac{dy}{dx} = \mu \Rightarrow \frac{x}{2} = 0.5$ $\left[\begin{array}{l} y = \frac{x^2}{4} \\ \frac{dy}{dx} = \frac{x}{2} \end{array}\right]$

$\Rightarrow x = 1,$

put x = 1 in equation $y = x^2/4$

$\Rightarrow y = \frac{(1)^2}{4} \Rightarrow y = \frac{1}{4} \Rightarrow y = 0.25$

y = 25 cm

6. An electromagnetic wave of frequency 5 GHz, is travelling in a medium whose relative electric permittivity and relative magnetic permeability bothare 2. Its velocity in this medium is ________ $\times 10^7$ m/s.

Sol. **15**

Given : f = 5 GHz

$\varepsilon_r = 2$

$\mu_r = 2$

velocity of wave $\Rightarrow v = \frac{c}{n}$ ....(1)

where, $n = \sqrt{\mu_r \varepsilon_r}$ and c = speed of light = 3×10^8 m/s

$n = \sqrt{2 \times 2} = 2$

put the value of n in we get

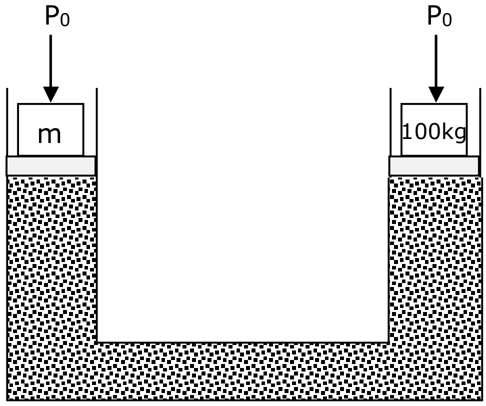
$\Rightarrow v = \frac{3 \times 10^8}{2} = 15 \times 10^7$ m/s

$\Rightarrow X \times 10^7 = 15 \times 10^7$

X = 15

7. A hydraulic press can lift 100 kg when a mass 'm' is placed on the smaller piston. It can lift ________ kg when the diameter of the larger piston is increased by 4 times and that of the smaller piston is decreased by 4 times keeping the same mass 'm' on the smaller piston.

Sol. **25600**



Atmospheric pressure P_0 will be acting on both the limbs of hydraulic lift.

Applying pascal's law for same liquid level

$$\Rightarrow P_0 + \frac{mg}{A_1} = P_0 + \frac{(100)g}{A_2}$$

$$\Rightarrow \frac{Mg}{A_1} = \frac{(100)g}{A_2} \Rightarrow \frac{m}{100} = \frac{A_1}{A_2} \quad ...(1)$$

Diameter of piston on side of 100 kg is increased by 4 times so new area = $16A_2$

Diameter of piston on side of (m) kg is decreasing

$$A_1 = \frac{A_1}{16}$$

(In order to increasing weight lifting capacity, diameter of smaller piston must be reduced)

Again, $$\frac{mg}{\left(\frac{A_1}{16}\right)} = \frac{M'g}{16A_2} \Rightarrow \frac{256m}{M'} = \frac{A_1}{A_2}$$

From equation (1) = $\frac{256m}{M'} = \frac{m}{100} \Rightarrow \therefore M' = 25600$ kg

8. A common transistor radio set requires 12 V (D.C.) for its operation. The D.C. source is constructed by using a transformer and a rectifier circuit, which are operated at 220 V (A.C.) on standard domestic A.C. supply. The number of turns of secondary coil are 24, then the number of turns of primary are _______.

Sol. **440**

Given

Primary voltage, V_p = 220 V

Secondary voltage, v_s = 12 V

No. of turns in secondary coil is N_s = 24

no. of turns in primary coil, N_p = ?

We know that for a transformer

$\Rightarrow \frac{N_p}{N_s} = \frac{V_p}{V_s}$

$\Rightarrow N_p = \frac{V_p \times N_S}{V_s} = \frac{220 \times 24}{12}$

$\Rightarrow N_p = 440$

9. An unpolarized light beam is incident on the polarizer of a polarization experiment and the intensity of light beam emerging fromthe analyzer is measured as 100 Lumens. Now, if the analyzer is rotated around the horizontal axis (direction of light) by 30° in clockwise direction, the intensity of emerging light will be________ Lumens.

Sol. **75**

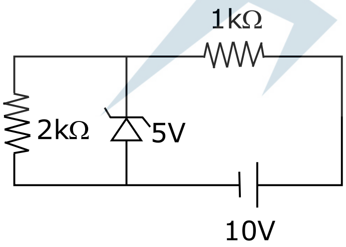
Given :I_0 = 100 lumens, $\theta = 30°$

$I_{net} = I_0 \cos^2\theta$

$I_{net} = 100 \times \left(\frac{\sqrt{3}}{2}\right)^2 = \frac{100 \times 3}{4}$

I_{net} = 75 lumens

10. In connection with the circuit drawn below, the value of current flowing through 2kΩresistor is ________ × 10^{-4} A.



Sol. **25**

In zener diode there will be o change in current after 5V zener diode breakdown

$\Rightarrow i = \frac{5}{2 \times 10^3}$

$\Rightarrow i = 2.5 \times 10^{-3}$ A

$\Rightarrow i = 25 \times 10^{-4}$ A